Symbols of Recovery – The Impact of Earthquake Images on Vigilance

How post-earthquake recovery images affect performance in the Christchurch population, four years later

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by N. J. Hancock

University of Canterbury

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Finally to the reader, the true inspiration for this research comes from my experiences in Christchurch at the time of the earthquake and moving forward as a resident. It is my hope that this study will provide some insight into the handling of any major disaster situation (war, earthquake, or other humanitarian disruption). While the actions that immediately follow the event sets the scene, but it is the moving forward, the recovery that needs to be managed appropriately for the whole community.

1. Abstract

This study explores the impact post-earthquake images from Christchurch, New Zealand inserted into a task requiring sustained attention or vigilance have on performance, self-reports of task-focus, and cerebra activity using functional near-infrared spectroscopy (fNIRS). The images represent the current state of Christchurch; a city struggling to recover from devastating earthquakes that peaked in February, 2011, killing 185 people, injuring hundreds more and causing widespread and massive damage to infrastructure, land and building in the region. Crowdsourcing was used to gather a series of positive and negative photos from greater Christchurch to be employed in the subsequent experiment. Seventy-one Christchurch resident participants (51 women, 20 men) then took part in a vigilance task with the sourced images embedded to assess possible cognitive disruptions. Participants were randomly assigned to one of three conditions: embedded positive pictures, embedded negative pictures, or embedded scrambled image controls. Task performance was assessed with signal detection theory metrics of sensitivity *A'* and *β''*. Individuals viewing the positive images, relating to progress, rebuild, or aesthetic aspects within the city, were overall more conservative or less willing to respond than those in the other conditions. In addition, positive condition individuals reported lower task focus, when compared to those in the control condition. However, indicators of cerebral activity (fNIRS) did not differ significantly between the experimental groups. These results combined, suggest that mind wandering events may be being generated when exposed to positive post-earthquake images. This finding fits with recent research which indicates that mind-wandering or day dreaming tends to be positive and future oriented. While positive recovery images may initiate internal thoughts, this could actually prove problematic in contexts in which external attention is required. While the actual environment, of course, needs to recover, support agencies may

want to be careful with employing positive recovery imagery in contexts where people actually should be paying attention to something else, like operating a vehicle or machinery.

2. Introduction

2.1. Research purpose and aim

The challenge in measuring performance in a city's population is that correlates are diverse (there is no way to de-confound tightly inter-correlated causes) and data is generally not captured which is useful for assessing performance impacts of environmental (land- or city-scape) features. Vigilance studies are designed to measure performance with experimental control, comparing changes over time and allowing manipulations to enable comparison due to specific manipulations or interventions.

Christchurch is a unique situation in New Zealand; it is a city in transition between a disaster and the future. Residents are faced daily with the continued impact of this transition and the images used in this study represent everyday situations encountered when moving about and operating in the city. In addition, a number of recovery agencies employ imagery from the recovery in attempt to promote the city and possibly improve positivity in the population.

By using a representative sample of the city's population, changes in performance due to different embedded images or representations of Christchurch may suggest links between environmental features or publically displayed imagery and actual objective performance. Experimental research in this area allows more control and precision in determining how environmental features or images impact people's cognition. Previous research indicates the earthquakes impacted cognition detrimentally (Helton & Head, 2012), but we do not know the longer term impacts which occur during the recovery process.

2.2. Background – Christchurch, New Zealand

Christchurch, New Zealand was established in the 1850's, by a settlement company from the United Kingdom. Although much of the coastal Canterbury plains were swampy and water logged, city planners drained, capped and built over streambeds, following a city layout drawn in England with little regard for the actual landscape. Christchurch is now the largest city in the South Island, with a population of approximately 360,000. The dominant architecture prior to 2010 was English inspired, with neo-Gothic influences signifying an Anglican heritage (Halliday, 2014), with many acres dedicated to parks and gardens. The buildings were part of the cultural and community identity of the Christchurch population.

Many of the city's iconic structures had religious significance, particularly the Anglican Christchurch Cathedral that held pride of place in the city's commercial centre. This icon crossed secular and religious boundaries and Christchurch was most often recognised by an image of the Cathedral, by residents and visitors alike. The city was considered safe and with its flat landscape, easy to move about in. Christchurch boasted an active night-life and the central city was a popular location.

New Zealand lies on a series of fault lines, sitting on the edge of the Pacific "Ring of Fire". Given susceptibility to earthquakes, building codes were strict by world standards, particularly the more modern structures. While earthquakes were not uncommon, they were generally weak and many considered Wellington, the capital city, to be at greatest risk of seismic event (McClure, Johnston, Henrich, Milfont, & Becker, 2015). The fault lines that caused the series of strong earthquakes in Christchurch (in 2010 and 2011) were previously unmapped and not part of the central Alpine Fault, running through the centre of the South Island - most believed that represented the greatest risk to the Canterbury region (Davey, 2011).

In September 2010, without warning, a high magnitude (magnitude 7.1) earthquake struck Christchurch at 4.37am. No loss of life was suffered but there was visible damage to buildings, and infrastructure. Though not fully realised at the time, the initial strong quake and subsequent aftershocks most likely also caused un-seen and undiscovered weaknesses throughout much of the city.

While the visible impact and disruption was relatively minor due partly to the depth and location of the earthquake, with schools and businesses only closing for a matter of a few days, psychologically there were intense feelings of vulnerability and uncertainly within the population (Gawith, 2011). Additionally Kemp, Helton, Richardson, Blampied, & Grimshaw (2011) reported sleep problems and cognitive disruption; more commonly in women, but generally increased throughout the population. Individuals questioned the integrity of buildings in and around the city. Although there were no earthquake-related deaths, perhaps tempering psychological distress, residents reassessed personal safety and were advised through the media to be prepared for further emergency conditions.

Substantial aftershocks continued, in the months after, peaking on 22 February 2011, shortly before 1pm with a violent 6.3 shallow quake centred in the Lyttelton basin, just 10 km from Christchurch's city centre. This resulted in significant loss of life and widespread infrastructural, landscape and building damage across the city and wider region (Moore, 2011). The Central Business District (CBD) was particularly severely affected through structural damage and failure of buildings. The estimated cost of the recovery and rebuild stands at approximately NZ $40 billion dollars. It was the costliest humanitarian disaster at the time of occurrence (Ferris & Petz, 2012). Along with the immediate emotional toll on residents, the disruption to work and city infrastructure was severe and on-going. Schools and businesses throughout the region were closed for weeks, some being closed permanently.

The events and aftermath in Christchurch represent a unique event, primarily due to the sustained and repeated extreme level of land and physical destruction to a large city (McColl & Burkle, 2012). The earthquakes led to an almost complete shut-down of the entire central city area (Kemp, Chan, & Grimm, 2013), which prior to September 2010, had been home to 6,000 businesses that employed over 50,000 people (The Field Connection, 2012). Many businesses relocated quickly after February 2011, some closed temporarily, and others closed permanently. Workforce requirements changed for some, and fewer workers were employed in the period immediately after the earthquakes, due partially to a failure of some businesses to re-establish and general business disruption.

Central government and the Christchurch City local authority were quick to establish a response team to oversee the demolition and reestablishment of Christchurch. However, there was been significant conflict between meeting civil commitments, public good and commercial pressures.

There will always be a period of psychological and emotional disturbance in the general population after any traumatic event (Neria, Nandi, & Galea, 2008). However, effects generally wane with time and progress, particularly as evidence of the disaster diminishes. Earthquakes do present a slightly different proposition however, in that a clearly defined end-point is lacking, with tremors continuing for a substantial time period, causing extended trauma and further destruction. While today there is obvious evidence of the city moving forward and rebuilding, the impact of the events in Christchurch and the public interest in the rebuilding of community as well as businesses has meant the evidence of the destruction remains well beyond the short term.

Performance in school, work or at home is affected by fatigue, stress and emotional state, along with other factors. As a general rule poorer performance occurs under negative effects; as such, one might expect a decline in performance after a severe earthquake. Helton and Head (2012) made use of the environmental opportunity to test individuals in a vigilance task prior to and after the September 2010 earthquake, finding as expected poorer performance post-earthquake. These events provide fertile ground for research; to map the effect on the population and learn through the process (Ruckidge, Blampied, Gorman, Gordon, & Sole, 2011; Osborne & Sibley, 2013).

Four years on from the series of earthquakes and thousands of aftershocks later, the city has a long way to go to achieve recovery and re-establishment. The impact is still highly visible on the cityscape and wider Christchurch area. Services and infrastructure throughout are still in a state of on-going repair and many buildings have yet to be demolished or repaired prior to re-occupation. This state of incompleteness will be long lasting, likely taking many years (Blakely, Birch, Aglin & Hayashi, 2011). While city residents have adapted to a post-earthquake Christchurch, constant reminders of the death and destruction are abundantly evident. Many businesses have relocated and have or continue to operate out of alternative locations, and the city no longer has the familiarity it once did. Some businesses are re-establishing in the CBD, however the commerce and retail areas remain permanently altered.

Infrastructure, particularly roading and underground piping, continue to require significant work. This work disrupts travel in and around the city, particularly in the central and eastern areas. Many individuals have remaining repair work to be completed on homes and businesses in addition to the stress in dealing with insurance companies and the earthquake commission. Life has returned to the constantly changing altered normal as repairs and rebuild take place but it exists as a changed state for everyone.

The earthquakes affected many of the city's historic and heritage buildings and urban streeetscapes. Continual debate has ensued around the preservation or demolition of buildings that are representative of the city’s cultural heritage and there has been a lot of resistance to change. It has been suggested that public good, in terms of collective memories may have been largely ignored in regard to those building in the race for progress and profit (Halliday, 2014).

In particular, for those who suffered personal loss or injury to friends and family, the Christchurch earthquakes may result in long-term stress. This distress may result in long-lasting clinical illness in some members of the population (Beaglehole, 2011). However, the lasting effects of traumatic events on a population that may affect work or study performance have had little attention. There are suggestions that physical and mental problems may continue for extended periods, often years. Lindell (2013) proposes that long-term consequences of disasters could include changes in risk perception and increased intrusive thoughts concerning hazards. These changes in risk judgement perhaps also affect optimism biases with studies finding that both are negatively affected by populations experiencing disaster (McClure, et al, 2015). These effects may have negative consequences for performance, throughout the population with associated effects on businesses and schools.

Christchurch presents a unique opportunity to investigate on-going effects on performance, particularly given the magnitude of damage caused and the time frame required to rectify and return the city to a newly formatted fully functioning community. The Canterbury Earthquake Recovery Authority (CERA), set up to monitor and manage the process of recovery, reported in 2013 that Christchurch city residents felt the earthquakes had a strong and negative impact on their everyday life and rated their quality of life lower than that of nearby districts (CERA, 2013).

2.3. Crowdsourcing

Each individual has a unique world view. That accompanied with the exponential increase in the use of social media and connectedness through the internet, which has meant that each person's voice can be heard.

Crowdsourcing by definition leverages population resources and combines bottom up and top down processes (Sloane, 2011). The word was originally coined by Jeff Howe, Wired magazine writer and was used to describe a process of using the collective intelligence of an undefined, large group rather than relying on a single individual (Howe, 2006). As the name suggests, a problem or discussion topic is distributed through web resources to a group for comment (bottom up process). These comments or solutions are then filtered by an individual or smaller group (top down process) for meaningful content. Crowdsourcing acknowledges that intelligence is not held exclusively by an individual and specifically recognises the wisdom of the crowd (Brabham, 2013).

The reliance on traditional immediate media sources like newspapers, magazines, and television has been supplemented with widespread use of crowdsourcing of information. Crowd ourcing of data is, by design, unfiltered and heavily biased to the supplying individual. However taken as a combined source, it can provide a wide breadth of perspectives unavailable with other forms of media information. Today smartphones and cameras are portable and easy to use. Wireless data networks span most of the globe and social media such as Facebook, Twitter and Instagram are widely and often instantly accessible.

While images of Christchurch are abundant across all media, the story behind the image is not always clear. In particular, images show a scene and tell a story based on an individual's (or group's) experience. Popular media does not always reflect general public feeling as the mundane and repetitive plight of the city's residents are rarely sufficiently sensational for mass media reporting.

Surowiecki (2004) claims that the wisdom of the crowds comes from the independence of each individual contributing as the group, differences within the group and through the combination of these contributions. Input from individuals is not averaged but stands as a set of responses; a collective work.

Crowdsourcing relies on a willing crowd or group of people who perform a task voluntarily (Estelles-Arolas & Gonzalez-Ladron-de-Guevara, 2012). Since the earthquakes, the local council and government representative organisations have attempted to engage the public for input into the future plans for the city. While it may be true that the pace of repairs cannot be influenced through public input, information on preferences on how to deal with demolition, empty spaces, roading disruptions, and construction may be vital in maintaining a positive outlook for the future of Christchurch.

2.4. Images and emotion

Emotion is a subjective, conscious experience influenced by environmental cues (Gross, 2013). While it can be argued that some environments trigger similar emotions in groups of people, each individual through experience and predisposition will react uniquely in any given circumstance.

Events elicit emotion unique to each individual based on their past, their experiences during and immediately after the event and how it continues or not to impact on daily life (Lazarus, 1991). Individuals also avoid or encounter environments based on choice or necessity, and interactions within the environment are shaped by the individual.

Images represent physical environments that may trigger memories and thoughts based on previous interactions. It has been famously said that an image paints a thousand words (Brisbane, 1911). With skilful photography it can take the viewer to the place, and time that the image represents.

2.5. Images and Christchurch

One cannot help but be moved by images, even without personal experience. Not only can we be taken to the past but images also may trigger daydreaming and thought processes about the future. There has been much speculation about how Christchurch will look in 2, 5, 10, 20 years and city authorities have gone to great lengths to engage the population in its planning and decision making. It may be that photos do not only elicit stress that may hinder performance, they may also disrupt cognitive resources with unrelated thoughts.

By using images sourced by the population and assessed in the vigilance task, it is intended that emotions elicited will contain some consistency. In particular, rather than presenting somewhat random images to generate emotive responses, these images represent everyday situations encountered by the studied population.

Previous research has used image banks validated for emotive eliciting properties, generally finding that generically negative images disrupt cognition (Helton & Russell, 2011). Given the prevalence of and at times inability to avoid ‘negative’ emotional stimuli in relation to the earthquakes in Christchurch, this study may have relevance to other populations recovering from disaster.

2.6. Vigilance tasks

Tasks involving sustained attention or vigilance pervade everyday life, from driving to work monitoring the vehicle’s performance and other road users, concentrating on a lecture at school, to the many tasks critical to safety and wellbeing that include air traffic control, security checking and health monitoring. Sustained attention assumes continuous maintenance of alertness and receptivity to detect a particular stimuli or change in stimulus

(Parasuraman, 1984). The critical target presentation is often barely noticeable, either due to short duration, almost undetectable changes or a combination of the two elements (Mackworth, 1957). The more common information transmitted is unassuming, requiring little or no action to be taken, but at any time, critical attention, reception and action are required.

With continued technological advances, the role of humans is becoming increasingly that of monitoring and processing extensive information presentations, essentially ‘waiting’ for critical events to occur. During these critical events, individuals are often required to make decisions and possibly manually react to the issue, before resuming the monitoring role. The rapid, sometimes instantaneous shift in performance requirements has presented challenges for psychology and human factor practitioners since the 1940’s.

Norman Mackworth (1948) is generally attributed with the first study and experimentation of vigilance. Specifically, he identified that vigilance declined as a function of time on task. This was particularly relevant at the time with Mackworth observing that radar and sonar operators monitoring a radar screen for irregular and rare targets (possibly representing enemy movement) often missed targets towards the end of their watch. This ‘miss’ could involve high risk to life. He engineered experimental simulations to investigate this ‘vigilance decrement’.

All sustained attention tasks suffer performance drops or vigilance decrement over time on watch (Hancock & Hart, 2002; Davies & Parasuraman, 1982). Typically the steepest decline in performance occurs in the initial 20 minutes after a watch begins (Davies and Tune, 1969). Performance is generally measured using hit rate (correct identification of critical stimuli), false alarm rate (incorrect identification of critical stimuli) and reaction time (time taken to identify and take action for critical stimuli) metrics. Many factors interact to affect task performance, but they generally fit within three areas: task parameters; extraneous environmental or situational variables and individual subject characteristics (Ballard, 1996). Manipulation of the task parameters involves creating an experiment with more than one condition, and measuring the differences between the conditions. Other factors are held constant either through environment/situation manipulation or through the use of a sample group representative of the generalised population.

Vigilance is a task involving perceptual uncertainty, and influences on performance are often enigmatic (Lynn & Barrett, 2014). Signal detection theory aims to clarify how an observer separates critical information from noise (Green & Swet, 1966). The task of discrimination is subject to the sensitivity of an observer to differentiate between the target and neutral stimuli and their willingness to respond to stimuli, or response bias. Sensitivity is influenced by signal salience and the individual's ability to 'see' the target stimuli. Response bias is dependent on individual factors (such as emotive state, focus, interest, etc.) and on the propensity to categorise stimuli as critical or not.

A common analogy is one of a radiologist examining a mammogram, the consequence of not flagging a possible tumour is in the worst case scenario, death for the patient. In this case the radiologist is likely to be more likely to respond 'yes' if in doubt than 'no', based on the consequences. Essentially during a vigilance task the observer is performing discrimination between stimuli: one represents the target, the other the distractor or neutral stimuli.

Taking sensitivity and response bias into account represents an attempt to understand performance metrics. While there are different methods to calculate these signal detection theory metrics, *A'* as a measure of sensitivity and β" are commonly used in vigilance studies (Stanislaw & Todorov, 1999).

There are competing theories proposed to explain this vigilance decrement, most notably the "mindlessness" theory (Manly, Robertson, Galloway, & Hawkins, 1999;

Robertson, Manly, Andrade, Baddeley, & Yiend, 1997) where the dropoff in performance is explained by a general reduction in alertness due to lack of varied stimulation; and the resource model (Davies & Parasuraman, 1982). Recent research (Grier, et al, 2003; Helton et al, 2005; Helton & Warm, 2008), supports the resource model in which available cognitive or attention resources are depleted over time (Kahneman, 1973). These resources are affected by a variety of environmental and individual factors, but eventually reach a state of exhaustion. Vigilance tasks typically measure performance without rest, meaning there is no period of replenishment and hence the somewhat linear decline in performance. Additionally, any other stimuli present during the vigilance task may compete for the limited resources, thus disrupting performance further (Helton & Russell, 2011; Ihssen & Keil, 2009). While it may seem that vigilance tasks are tedious and boring, subjective and physiological measures have also suggested that they are in fact stressful (Warm, et al, 2008), indicating further weaknesses' in the mindlessness theory.

Subscribing to the resource theory, I propose to examine the long-term effect of the earthquakes and on-going disruption in Christchurch on vigilance performance using post-earthquake images as interrupting stimuli between vigilance blocks.

2.7. Vigilance and task-irrelevant images

Previous research has investigated the effect of emotive visual stimuli on performance (Ossowski, Malinen, & Helton, 2011; Helton & Russell, 2011; Flood, Naswall, & Helton, 2014). Although images have been chosen for their general emotive eliciting properties, researchers have largely neglected the use of specific 'population' relevant images.

'Population' relevant images appeal to the population being investigated and are based on shared experience. While they may generate thought and even empathy in the general population they will not have the same emotive or thought generating effect without having had the first-hand experience (Hein & Singer, 2008). It is similar to viewing images of a car crash, a war, and a prison; to those without the experience; while it may evoke emotion and empathy, the meaning and full emotive impact is significantly weakened.

Most important to generating ‘population’ relevant images is understanding the shared experience of the population, in this instance Christchurch residents and listening to the frustrations and the positive experiences in the process of moving forward. In this instance using crowdsourcing of images has immensely aided the process. Rather than assuming that popular media or individual bias represent the population, the population has been able to represent itself and its breath of viewpoints.

Any emotional stimuli captures attention and thus competes with the limited cognitive resources required for the vigilance task. Previous studies have used irrelevant negative stimuli (Helton & Russell, 2011; Contreras, Megias, Maldonaldo, Candido, & Catena, 2013), finding that particularly negative images capture attention and are detrimental to vigilance performance. Additionally research suggests that conscious thoughts may also compete for limited resources and thus further limit cognitive ability on other tasks (Helton, Dorahy, & Russell, 2011; Ossowski, et al., 2011). While the interference from task-irrelevant stimuli is often restricted to the period immediately following presentation, some studies have reported a carry-over facilitation of performance (Contreras, et al., 2013; Flood, et al, 2014).

All conditions in this vigil include random, brief presentation of task-irrelevant images. The positive and negative image condition contain relevant (to the sample population) images of places, spaces and things within their city embedded in a vigilance task to examine disruptive influences as well as promoting ‘daydreaming’ or mind wandering, resulting in task-unrelated thoughts.

2.8. Stress

Vigilance is by nature, stressful. (Helton, 2002; Warm, Parasuraman & Matthews, 2009), although there is considerable individual variation (Matthews & Campbell, 2009).

Most commonly stress state is measured psychologically, through self-report questionnaires. While these rely on accurate recall of past state, research has shown good correlates when measured with more objective physiological measures (Matthews, Campbell et al. 2002).

It has been well reported that stress reduces human performance (Eysenck & Calvo, 1992), although there is some evidence that on occasion moderate stress may actually enhance performance (Jamal, 1984). However, mental health workers agree that too much stress may have long-term consequences such as post-traumatic-stress-syndrome (PTSS). While PTSS is a clinical diagnosis reserved for individuals reporting severe and long-lasting symptoms, the long-term effect of a disaster on the general, non-clinical population is less clear.

There has been much discussion in the mass media and within the community about the perceived, non-clinical mental effects of living in a post-earthquake 'transitional' city, however there is little clear evidence that this mental fatigue is having any real effect. Generally the negative effect of a disaster wanes over time (Cardena & Spiegel,1993), however this may not be the case in the face of constant reminders. As might be expected, participants in a sustained attention task have performed worse post- when compared to pre-earthquake levels (Helton and Head, 2012). Yet to be determined is whether performance under similar test conditions continues to be effected and could be translated to work and study environments.

Residents within Christchurch and the surrounding areas are still faced with physical and mental stress and fatigue associated with the earthquake (Spittlehouse, Joyce, Vierck, Schluter & Pearson, 2014). While much progress has been made in the time between the earthquakes and the present, the effect is ever present, particularly within the central city area which is still dominated with empty sites, partially demolished buildings, road works and a general lack of normal city scape and activity.

It is established that individuals respond differentially to stress and the effect of the images may be moderated by prior experience (e.g. where they were in Christchurch at the time of the earthquake, salient death as a result of the earthquake, extent of disruption to everyday life, etc.) in addition to individual response strategies. Additionally, corollary with continual exposure to fearful stimuli, individuals may become desensitised, it may also be that Christchurch residents are no longer so negatively affected by reminders of the earthquakes.

Using previous studies as reference, this study uses an abbreviated set of items from the Dundee Stress State Questionnaire (DSSQ, Matthews, et al, 1999), focusing on those issues relevant to the vigilance study ((Szalma, Warm et al. 2004), in particular, task-focus (task-irrelevant thoughts, task-relevant thoughts and concentration). The DSSQ and abbreviated formats of the DSSQ have been extensively used and well validated particularly in similar sustained attention studies, allowing inter-study comparisons (Flood, et al, 2013; Finkbeiner, Wilson et al, 2014). While stress is a complex multi-dimensional state, we are primarily interested in the cognitive components which may represent internal competitors for cognitive resources (day-dreaming, rumination, or mind-wandering).

2.9. Functional Near-Infrared Spectroscopy

Declines in performance can result in loss of life. Just as Mackworth (1948) noted, a critical stimulus 'miss' is detrimental to health. Research suggests there is significant correlation between cerebral blood flow and neural activity when performing mental activities (Warm, Matthews et al. 2009). The ability to understand and measure real-time physiological correlates to performance or task engagement may allow detection and intervention when attention wanes.

Bogler, Mehnerts, Steinbrink and Haynes (2014) discuss real-time methods (EEG and fMRI) to measure neural demands. Functional MRI (fMRI) neuroimaging represents the gold standard. fMRI measures brain activity by detecting the associated blood flow changes (Shah, Anderson, Lee, & Wiggins, 2010), as cerebral blood flow and neuronal activated are coupled. Studies have shown that attentional performance is highly correlated with blood-oxygen-level dependent (BOLD; the primary form of fMRI) contrasts, particularly in the pre-frontal and parietal areas (Bogler, et al, 2014; Harrivel, et al, 2013)). Equipment cost and practical or logistic issues render the likes of EEG and fMRI impractical for widespread use in experimental studies. Additionally EEG correlates with performance in sustained attention tasks in the normal population are not consistent, particularly when measuring small changes (Oken, Salinsky, & Elsas, 2006). Functional near-infrared spectroscopy (fNIRS) represents a cost-effective, portable and ease of operation alternative to measure real-time cerebral activity.

The equipment used (Nonin EQUANOX^{TM} 7600 Near Infrared Cerebral Oximeter) is a portable optical neuroimaging machine. This method is non-invasive and non-confining for the participant and presents no long-term detrimental effects (Boas, et al, 2004). It measures cerebral tissue oxygen saturation (rSO_2) levels in the left and right hemispheres of the frontal areas of the brain. These measures have similar characteristics to the BOLD contrasts revealed by fMRI techniques.

Two sensor pads are placed on a participant's forehead, where they remain for the duration of the task. These pads emit small infrared light pulses frequently throughout the task, sensing changes in blood oxygenation. These recordings can then be matched to performance data gathered to correlate the relationships between activity in the brain, performance on the vigilance task and to some extent cognitive state.

Previous studies have shown fNIRS readings can detect moment to moment changes in task engagement, revealing when an individual is disengaging from the task (Harrivel, et al, 2013). Typically, as information processing demands increase there is a corresponding increase in tissue oxygenation (Stevenson, Russell, & Helton, 2011). It follows that a decrease in tissue oxygenation corresponds with a decrease in information processing and given demands in a vigilance task are intentionally maintained at a high level throughout, any decrease is likely to represent task disengagement.

Additionally research suggests that activity is greater in the right hemisphere than in the left hemisphere during vigilance task (Warm, et al, 2009).

2.10. Hypotheses

Hypothesis 1 – The vigilance decrement will occur relative to time-on-task, regardless of the condition.

The task is one involving sustained attention over a period of time, and as such I expect that performance metrics will reflect a decline in detection of targets and increased reaction times for those detections.

Hypothesis 2 – There will be a significant difference in vigilance performance between the image and no image conditions.

Though difference is anticipated, the direction of the difference is not clear. Some studies have found arousing images may actually improve performance sometime after presentation (Flood, et al, 2014). If the negative images induce fearful thoughts about the earthquake, increasing arousal the vigilance decrement may be attenuated.

Alternatively the negative images may increase rumination and task unrelated thoughts which would distract from the task and performance decline on task would amplify (Ossowski, et al., 2011). Given the specific nature of the images embedded in the vigilance (predominantly structural damage and disruption, with no obvious personal injury or loss of life) it is unlikely that they will be sufficiently arousing to heighten performance.

Hypothesis 3 – There will be greater right hemispheric activation relative to left hemisphere regardless of the condition.

Current research suggests that vigilance tasks result in an increase in neuronal activity particularly in the pre-frontal areas, and that the right hemisphere is more active than the left.

Hypothesis 4 – There will be a significant difference in self-reported task focus.

It is anticipated that the negative condition images will trigger increased task-unrelated thoughts and so result in lower task focus scores relative to the control and positive conditions. In addition much research suggests that humans have a preference for future-based mind-wandering (Smallwood, Schooler, Turk, Cunningham, Burns, & Macrae, 2011), meaning that the positive images may stimulate task-unrelated thoughts. In summary both image conditions participants are expected to report less ‘task focus’ than no-image participants.

3. Method

3.1. Image sourcing

Initial research focused on sourcing both positive and negative emotion-inducing images of post-earthquake Christchurch. Images were obtained over the year long period, beginning September 2013 and ending September 2014, corresponding to 3-4 years post the February, 2011, 6.3 magnitude earthquake.

The photos were obtained through crowdsourcing techniques. Participants were recruited through social media and email. Instructions for responses were purposefully vague to ensure any researcher bias was minimised and to maximise individual interpretation; to take photos of places, spaces or things that engendered a feeling of positivity or negativity regarding the rebuild/recovery process, 3-4 years on from the devastating earthquake. The images were then uploaded to a Facebook page or email address. Although many of the supplied images or themes were repeated through multiple participants, by design they were specific to each individual.

One hundred and four images were obtained (76 positive and 28 negative, supplier classified), from 21 individuals representing a variety of themes. Each individual agreed to the reproduction of their images by uploading an accompanying statement detailing that fact. Images were stripped of any metadata to prevent participant identification and then rated and organised by a focus group into themes by emotive state. These themes were then consolidated into coherent groupings.

3.2. Images embedded in vigilance task

The focus group sorted and grouped photos. Any images that featured in both positive and negative categories (e.g. Cardboard cathedral; a temporary replacement for the iconic Christchurch cathedral) were discarded due to the ambiguity of emotive response for the purpose of vigilance embedment. Ten positive and ten negative images were selected that represented the clearest and most negative or positive emotive responses to be used in the vigilance experiment.

3.3 Image rating

To test whether the crowdsourced images used in the vigilance conditions did actually represent the appropriate response; positive or negative from the Christchurch resident population, I conducted a rating check.

Fifteen (7 male, 8 female; *M* age = 40.8 years [SD = 13.4 years]) new participants were asked to rate the 20 image stimuli used in the vigilance task in addition to 12 extra images on a scale of 1 to 7, with 1 being extremely negative and 7 being extremely positive.

3.4. Vigilance Task

3.4.1. Participants

A total of 71 (51 women; 20 men) participants were recruited through social media site Facebook and through flyers around the University of Canterbury. Participant ages ranged from 18 to 75 years (*M* = 35 years, *SD* = 15 years) and were all given $10 NZD vouchers valid at a local shopping centre. Experimental requirements for participation were set at 18 years or over, normal or corrected to normal vision. The experiment initially specified only right-handed participants, however some left-handed participants were tested. These individuals were removed for the fNIRS portion of analysis due to cortical differences with right-handed individuals.

All participants had resided in Christchurch for at least one year prior to the experiment and most (88%) were resident at the time of the significant February 2011 earthquake. This requirement existed to ensure that the specific nature of the embedded photos were relevant to the sample population and representative of the general adult Christchurch population.

3.4.2. Materials and procedure

Participants were tested individually in a small room without external windows but illuminated with ceiling-mounted fluorescent lighting to minimise any glare from the monitor. Participants were provided with an information sheet explaining the experiment and procedure. A verbal explanation was also given, particularly noting the physiological measuring equipment used (Near Infrared Cerebral Oximeter) to ensure participants were aware that it was a non-invasive procedure and so reduce any associated anxiety. All participants signed a sheet indicating their willingness to take part in the experiment, and were subsequently requested to turn any mobile phones off and remove any time-keeping devices from their person.

Participants were instructed to adjust the seating position in front of an eye-level computer monitor (270mm x 340mm) to a distance of 40-50cm away. Particular care was taken to ensure participants were able to comfortably use the space-bar on the keyboard with minimal movement. Two sensor pads connected to a Nonin EQUANOX 7600 Near Infrared Cereral Oximeter, were placed on left and right sides of the participant’s forehead and secured with an adjustable head band. Care was taken to place the sensors symmetrically, avoiding any hair that may interfere with the signal, and away from the central nasal cavity. Readings were checked on the Oximeter for approximate symmetry and acceptable range readings, with adjustments being made as required prior to recordings. Participant number and random condition assignment, ensuring gender balance (negative, positive or control) were entered on the computer prior to a five minute baseline recording commencing. Participants were advised to relax and clear their minds as much as possible, refrain from movement and speech while fixing their eyes on the blank computer monitor. To maximise settled and stable baseline readings the final 60 seconds of data were used in the subsequent analysis (Aaslid, 1986).

On completion of the quiet baseline period, participants were informed via an information screen on the monitor that the experiment was about to commence. Additionally, verbal instructions were provided to ensure understanding of the task. Representative displays indicated the position of the target and neutral ovals in relation to the central fixation cross. The ovals would appear randomly at one of the four locations, two locations to the left and two to the right of the fixation cross. Written descriptions were displayed on the screen and indicated whether participants should press the spacebar or withhold response to presented stimuli. This was followed by a one minute practice session. Feedback for incorrect responses was provided by screen text during the practice period. At completion of the practice, participants were advised with another information screen that the experiment was beginning and no feedback would be provided. To prevent confusion, all were told that they may see images presented on the screen and that these were part of the experiment.

The detection task used resembled a previous experiment by Caggiano and Parasuraman (2004), using symbolic rather than alphanumeric discrimination. Participants monitored the repetitive display of a small black oval shape (1.69 x 1.40 mm) displayed for 190 ms at the rate of one every 990 ms on a grey background (E-prime colour grey). They were instructed to press the spacebar whenever an oval appeared at a far target location which was 25 mm to the left or right of a central fixation "+" (E-Prime silver Arial 16 font) and to make no response to neutral (or distractor) near ovals placed 20 mm from fixation. Correct responses made within 990 ms of the onset of an oval at the target location were classified as hits, responses made within 990 ms to ovals at the near locations were classified as false alarms. Target probability was $p = 0.18$ of trials and were presented equally often on the left and the right, as were neutral locations. Each participant was presented with a different random order, but the same set of positions.

The task was 19.22 minutes in duration and consisted of 5 periods of approximately equal times. The periods of watch comprised of three types: periods one consisted of the vigilance task alone (3.46 minutes); periods two and three (4.32 minutes each) contained vigilance interrupting images; and periods four and five (3.46 minutes each) consisted of the vigilance task alone again. Periods two and three were longer than the other periods to prolong time with image presentation and allow comparison with similar research by Flood, et al, (2014). The task was arranged in this manner to enable the impact of images as they appeared and the residual effect afterwards to be examined. The entire 5 periods were presented as a continuous block.

In each condition, ten images were presented for 1000ms each, equally spaced within the vigilance task, during the image presentation blocks. The images were displayed in random order drawn from a list, with all ten being seen by each participant. The pixelated images viewed during the control condition were a random selection from the 20 positive and negative images. The pixelated images (see Figure 1, for an example) were scrambled sufficiently to render the content unidentifiable, but to mimic tonal qualities of the positive and negative images.

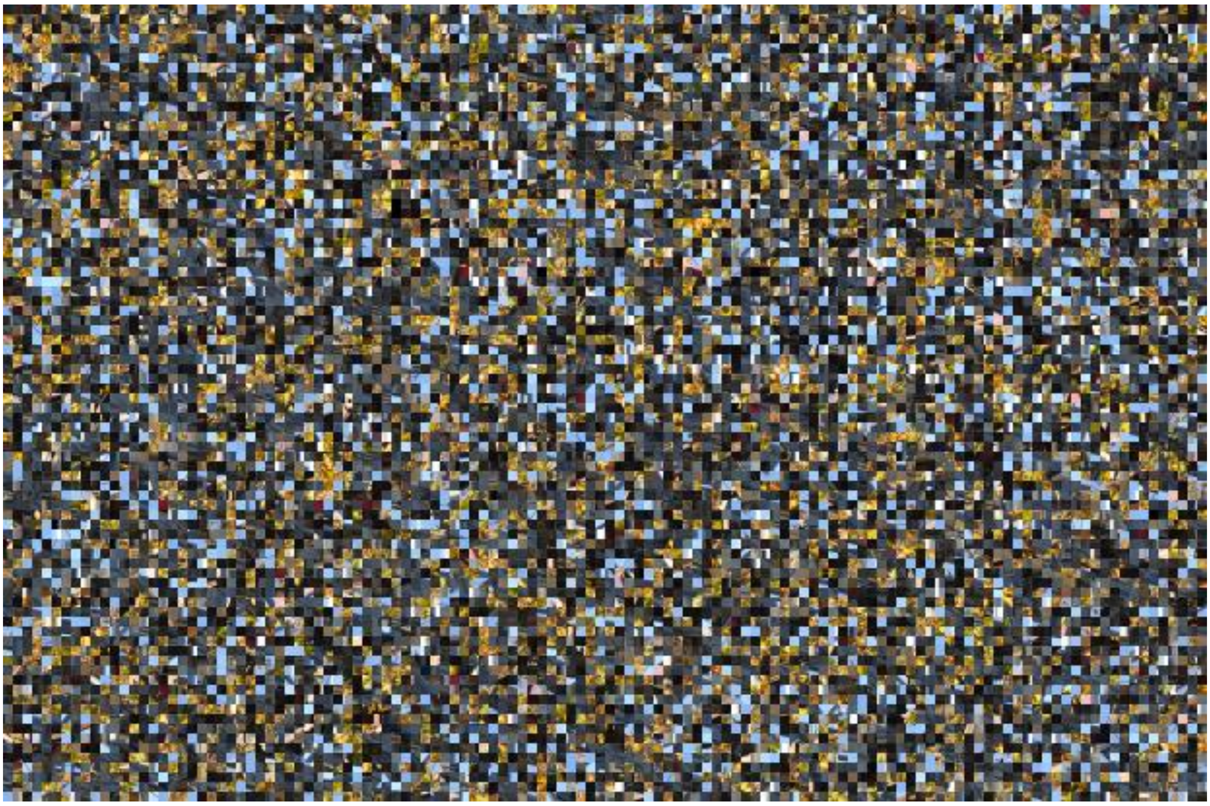

Figure 1. Example of a pixelated control image

The vigilance task used involved participants responding by pressing the spacebar to rare ‘far’ targets amongst common ‘near’ stimuli. The experiment consisted of three conditions; positive, negative and control. The negative and positive images consisted of those selected through crowdsourcing by the focus group. The control condition images were randomly selected scrambled positive or negative images. Scrambled or pixelated images were used to ensure the same contrast, colour and light conditions to the positive or negative conditions, and yet be void of any identifying characteristics and therefore meaning. This allowed comparison between conditions by ruling out the effect on performance of a disruptive image alone.

Immediately following completion of the task the head band and sensors were removed. All participants then completed a combined 17-item short NASA Task Load Index (TLX) and Dundee Stress State Questionnaire (Wilson, Finkbeiner, de Joux, Head & Helton,

2014) indicating subjective measures on a 0 – 100 scale. This was followed by a demographic, subjective effect of earthquake scale (at impact and current), and an optimism scale.

Following the questionnaires, participants in the positive and negative conditions were asked to recall any images they remembered seeing in the vigilance task. Response time was limited to three minutes. No indication was given regarding actual number of images, or feedback on correct identification during the recall. Only those responses that were clear, legible and descriptively correct of the images viewed were recorded. Afterwards they were debriefed and provided compensation for their time prior to leaving.

4. Results

4.1. Image rating check

The images from the positive condition (*M* = 5.08, *SD* = .67) were rated significantly more positive than the images from the negative condition (*M* = 3.07, *SD* = .62), $t(18) = 6.96$, $p = .000$, *Mdifference* = 2.01, 95% Confidence interval [1.41, 2.62].

4.2. Vigilance performance

Vigilance performance is measured using hit rates (correct detection of target stimuli), and false alarms (incorrect response to non-target stimuli). Average hit rates and false alarm rates are displayed in Table 1 by condition and period in Appendix A. From the hit and false alarm rates I calculated the signal detection theory metrics *A'* and β'' to investigate the underlying mechanism of the performance data. *A'* is a metric of sensitivity (how well the individual can separate target signals from noise) and β'' is a metric of response bias (the willingness of the individual to make a response or not) with scores ranging from -1 to +1 (-1 refers to an extreme bias to respond (liberal); +1 an extreme bias not to respond (conservative)). I conducted two 3 (experimental condition) by 5 (period of watch) mixed (split-plot) analysis of variance (ANOVA) for *A'* and β''.

I was particularly interested in whether there were changes in these metrics over the five periods and whether these trends were different depending on experimental condition. The data was analysed with a priori orthogonal polynomial contrast or trend analysis (Keppel & Zedeck, 2001). Due to the structure of the experiment: no image, image and then no-image again, I limited trends to a cubic level (two inflection points). The particular advantage of a priori orthogonal contrasts is that sphericity is not a concern given they are 1 degree of freedom contrasts.

The results for perceptual sensitivity (*A'*) were statistically significant for period; $F(4,272) = 21.80$, $p = .000$, $\eta_p^2 = .243$, and more specifically there was a statistically significant linear trend for period, $F(1,68) = 47.88$, $p = .000$, $\eta p^2 = .413$. The main effect for condition, $F(2,68) = .16$, $p = .850$, $\eta p^2 = .005$, and the interaction of condition and period $F(8,272) = .64$, $p = .747$, $\eta p^2 = .018$, were statistically insignificant. The data is displayed in Figure 2.

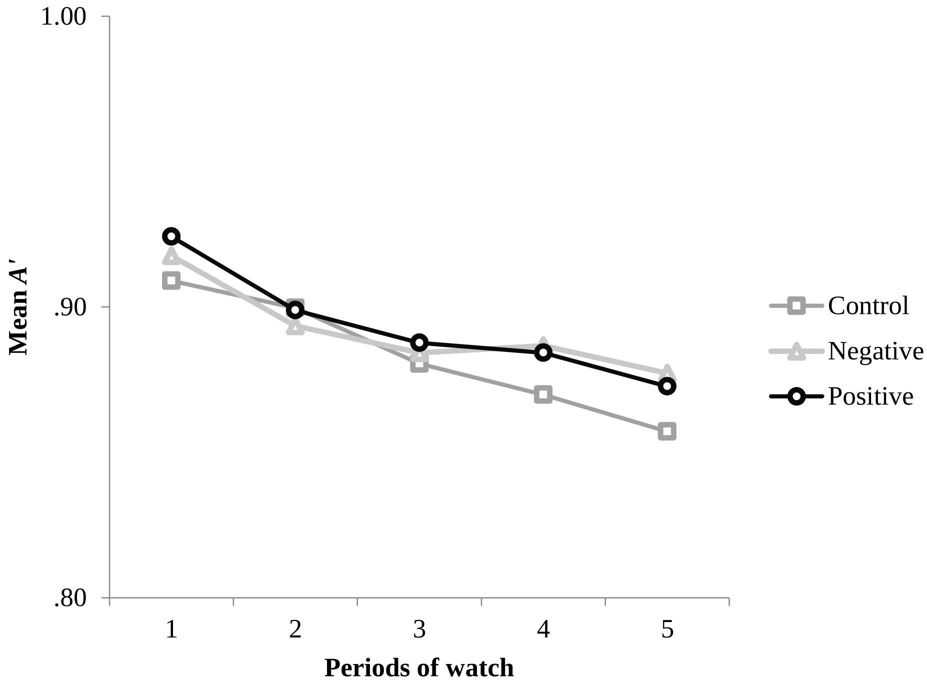

Figure 2. Mean perceptual sensitivity (*A'*) over time on the vigilance task.

I found a statistically significant main effect of period for β'' (response bias); $F(4,272) = 50.42$, $p = .000$, $\eta p^2 = .426$ with a statistically significant linear trend, $F(1,68) = 79.61$, $p = .000$, $\eta p^2 = .539$, a statistically significant quadratic trend, $F(1,68) = 44.50$, $p = .000$, $\eta p^2 = .396$, and a statistically significant cubic trend, $F(1,68) = 25.67$, $p = .000$, $\eta p^2 = .274$. Figure 3 summaries the mean values for β'' over the five periods.

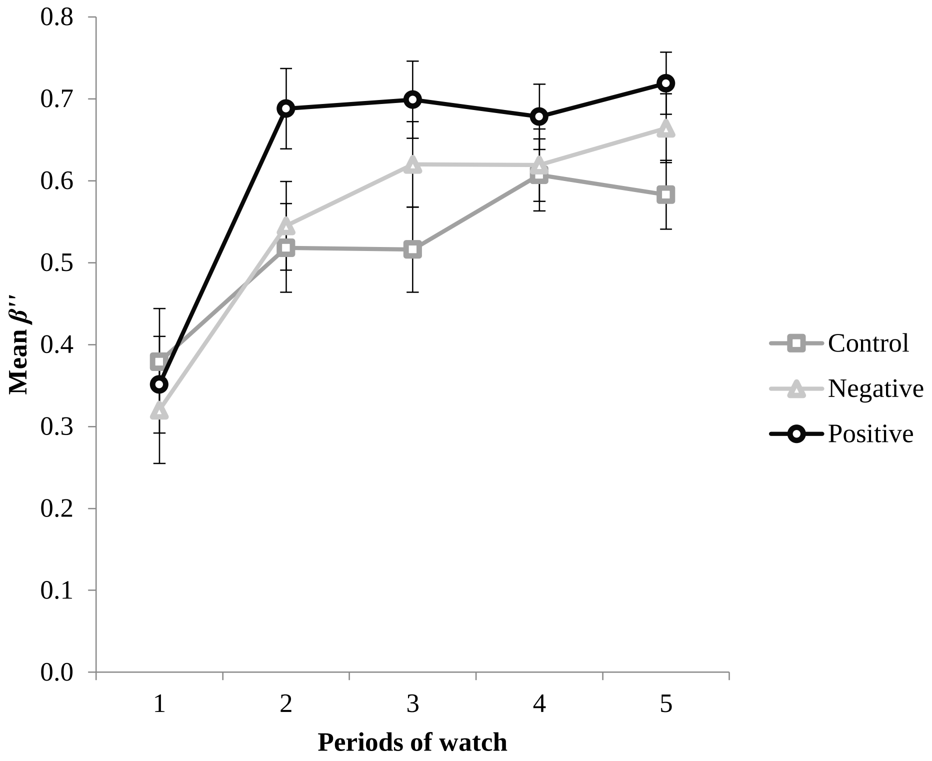

Figure 3. Mean response bias *β''* over time on vigilance task. Error bars are standard errors.

Additionally there was a significant condition by period interaction; $F(8,272) = 2.47$, $p = .014$, $\eta p^2 = .068$, with a statistically significant quadratic trend, $F(2,68) = 3.13$, $p = .050$, $\eta p^2 = .084$, and a statistically significant cubic trend, $F(2,68) = 7.18$, $p = .001$, $\eta p^2 = .174$. There was no statistically significant main effect for condition, $F(2,68) = 1.73$, $p = .184$, $\eta p^2 = .049$.

While the above analysis indicate there is an interaction between period and condition for *β''*, further analysis is required to discover which of the three conditions are different. I conducted a set of contrasts between the three conditions for each period. In each case I compared the negative condition with the control condition and the positive condition with the control condition (a conservative adjustment to alpha would be to interpret anything less than $p = .025$ as statistically significant).

The results for Period 1 (pre-image) were not statistically significant, $F(2,68) = .21$, $p = .813$, $\eta p^2 = .006$. Period 2 comparisons were statistically significant, $F(2,68) = 3.26$, $p = .044$, $\eta p^2 = .088$. The simple contrast comparing negative condition with control condition was not significant but positive with control was statistically significant, $p = .022$. Period 3 was also statistically significant, $F(2,68) = 3.43$, $p = .038$, $\eta p^2 = .092$. Again the contrast indicated negative and control conditions were not significant, but positive and control conditions were statistically significant, $p = .011$. Neither period 4, $F(2,68) = .84$, $p = .437$, $\eta p^2 = .024$, nor period 5, $F(2,68) = 2.86$, $p = .064$, $\eta p^2 = .078$ were statistically significant.

In summary, *β''* result were statistically significantly different for periods 3 (image) and 4 (first post-image period), with the contrast analysis revealing that the positive condition was statistically significantly different from the negative and control conditions. The result suggests the positive condition participants are highly biased not to respond or withhold responses to both critical and non-critical stimuli.

4.3. Physiology

The percent change in regional oxygen saturation (rSO_2) was used to assess relative cognitive demand compared to a pre-task resting baseline measure in a similar manner as previous studies (Stevenson, Russell, & Helton, 2011). A score of 0 would indicate that there was no change relative to baseline measures. The reason the degrees of freedom differed between the fNIRS tests and the performance tests is because left handed individuals were removed from the analysis as they may not have the same lateralization as right-handed individuals and one signal loss for one right-handed individual.

I performed a 2 (hemisphere: right vs left) by 3 (condition: control, positive, negative) by 5 (period) ANOVA on the rSO_2 data. Analysis revealed statistically significant results between hemispheres, $F(2,252) = 7.47$, $p = .008$, $\eta p^2 = .106$. Right hemisphere oxygenation was higher than left hemisphere (Right hemisphere *M* = 2.126, *SD* = 3.05; Left hemisphere *M* = 1.344, *SD* = 3.16). There was also a statistically significant result for period of watch, $F(4,252) = 10.65$, $p = .000$, $\eta p^2 = .145$ but no significant interactions.

Additionally there was a statistically significant linear trend for period of watch, $F(1,63) = 15.76$, $p = .000$, $\eta p^2 = .200$. Again there were no significant interactions.

The results indicate that there was no statistically significant differences in rSO_2 between conditions. It did show however that cerebral oxygenation decreased throughout the task from initially higher than baseline levels (see Figure 3) and that the right hemisphere higher levels of rSO_2 compared to the left hemisphere.

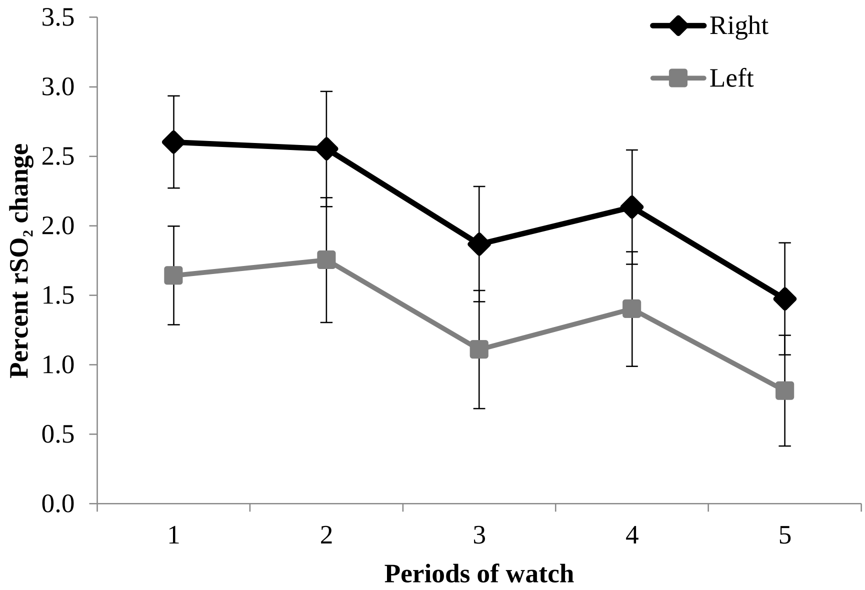

Figure 4. Combined mean oxygenation scores for the left and right hemispheres over the periods of watch. Oxygenation scores are based upon percent change relative to base line. Error bars are standard errors

4.4. Subjective measures

A ‘task focus’ metric was calculated in the same manner as used by Wilson, et al (2014), by averaging three items: task related thoughts; task unrelated thoughts (reversed scored) and concentration. All the scales were measured on the same response index (0-100) so raw scores were used. A high score on task focus composite was considered to indicate the person was focused on the task. Cronbach Alpha was used to test for reliability or internal consistency of the composite metric; α. = .67. While this value is below the usual threshold value of α = .7, this is likely a result of the small number of items used (Tavakol & Dennick, 2011). Figure 4 shows the mean Task Focus scores for each experimental condition.

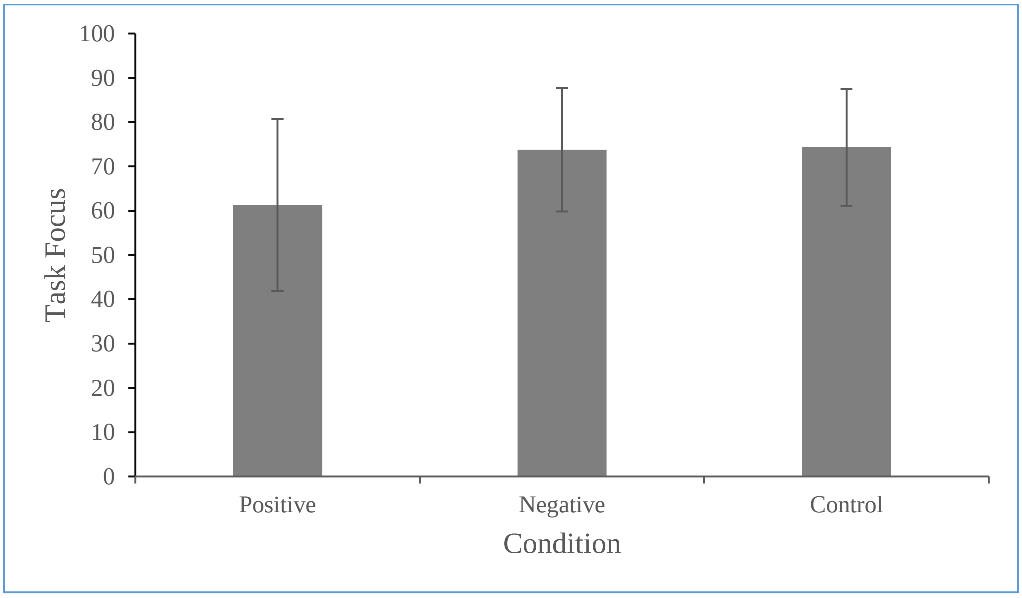

Figure 5. Mean and standard deviation task focus for experimental condition. Error bars are standard errors

This scale was analysed with a 3 (condition) way ANOVA. The main effect of condition was statistically significant, $F(2,68) = 5.27$, $p = .007$, $\eta p^2 = .134$. A set of contrasts were conducted comparing positive and control conditions in addition to negative and control conditions. Results show a significant difference between positive and control conditions, $p = .006$, but no significant difference between negative and control conditions, $p = .903$.

Task focus for the positive condition ($M = 61.32$, $SD = 19.40$) was significantly lower than control condition ($M = 74.35$, $SD = 13.18$), $t(47) = -2.68$, $p = .010$, *Mdifference* = -13.03, 95% Confidence interval [-22.8, -3.3], Cohen's *d = .80 with pooled SD*

5. Discussion

5.1. General Discussion

The vigilance experiment shows all the hallmarks of a vigilance test with anticipated decrements across all conditions, supporting Hypothesis 1, that performance would decline as a function of time on task. Additionally Hypothesis 3 was supported with rSO_2 readings mimicking results in other studies with higher right hemisphere activation (Helton, et al 2007; Parasuraman, Warm, & See, 1998) along with a generalised increase in pre-frontal oxygenation, indicative of cortical activation.

However, the results only offered partial support for Hypothesis 2, that there would be significant differences in performance between either positive or negative image conditions and the control. It was expected that both sets of images would attract attention relative to the pixelated (control condition) image and interfere with processing the subsequent stimuli. In particular it was predicted that negative images would trigger negative thoughts and memories relating to the earthquake, and in doing so have a negative impact on performance in contrast to other conditions. Additionally there was no support for positive images eliciting positive thoughts and attenuating the decline in performance over time. These results are contrary to similar studies where negative images caused a reduction in performance efficiency (Helton, & Russell, 2011) and research by Flood, et al (2014) who found performance decline was actually attenuated after the period of image presentation.

While other studies have used highly arousing images (e.g. naked people, fire, death), the images used in the present study do not have the same extreme qualities. This may have meant they were not sufficient to capture attention in the same way.

Using signal detection theory to investigate the decision making process revealed no differences in perceptual discrimination (sensitivity; *A'*) between the experimental conditions.

This suggests that individuals in all the groups were approximately equally able to distinguish the critical from neutral stimuli. The most compelling finding in the current experiment was the significant statistical difference in response bias between the conditions, surprisingly with those viewing the positive images were more biased towards non-response to either target or neutral stimuli. Essentially they became unresponsive, conservative or tuned out from the vigilance task.

With a difference in perceptual discrimination unlikely as an explanation for the conservative response bias, one might expect that the task disengagement would be evident in the physiological measures (rSO_2). However, I found no corresponding differences in cerebral oxygenation between experimental conditions. While a failure to find differences is not the same as supporting a ‘no-difference’ finding, it suggests that the three conditions were using similar cognitive resources.

Subjective measures may provide some insight into why individuals in the positive image condition were reluctant to respond to any stimuli. Self-report task focus scores of individuals in the positive condition were statistically significantly different from individuals in negative and control conditions. This finding suggests that the positive condition participants were using some of their cognitive resources for purposes other than the vigilance task. Negative condition participants however reported similar task focus to those in the control condition.

In summary positive image participants performed similarly to participants in the other conditions with the exception of their response bias. These same participants reported a significantly lower task focus, but physiological measures were similar across all conditions. If utilised cognitive resources were not all engaged in the vigilance task what additional function were they performing?

The combination of results suggests that while the task itself may have been stressful and engaging, resulting in resource depletion, the positive images likely triggered mind wandering episodes. Recent research suggests that the vigilance decrement may in fact be subject to a combination of resource depletion and mind wandering (Thomson, Besner, & Smilek, 2015). It may not be that the task itself was insufficiently demanding or engaging, but that the positive images triggered thoughts of the future. The specifics of these thoughts are not recorded as they may be subconscious, and certainly difficult to remember post-task. However, some task-unrelated thoughts are occurring suggesting mind wandering.

Mind wandering may be induced by the positive photos as they could conceivably represent progress and the future direction for the city. Miles, Karpinska, Lumsden, et al (2010) found using symbolic prompts they were able to induce self-report future or past-centred mind wandering respectively. Potentially if symbolic future presentations are able to stimulate such mind-wandering, images that represent the future may trigger similar responses.

Additionally research has suggested that mind wandering more frequently involves time travel to the future rather than the past (Ye, Song, Zhang, & Wang, 2014). This would further support the decreased task focus for the positive condition participants. In particular in contrast with other forms of mind wandering, future-base mind wandering uses more cognitive resources. This is due to it involving more self-talk, and structured, concrete sequences of thought (Stawarczyk, Cassol, & D’Argembeau, 2013). Although not significant, hit rates and false alarm rates were lower for the positive group, indicating an unwillingness to respond to any stimuli, they did not show any indication of lesser neuronal activity. In fact it suggests that instead of using the cognitive resources for the task they were focused on planning for and thoughts for the future.

An alternative suggestion is that the positive images were less arousing than the negative images. This may have increased opportunity for positive image participants to engage in mind wandering.

5.2. Real world implications

There are many workers employed on construction sites, involved in the rebuild and repair, as well as individuals travelling in and around the city. The suggestions that this study raises present concern for health and safety of these individuals. Mind wandering to some extent prevents individuals from full focus on the task they are primarily involved in.

While business performance implications may impact profitability and subsequently employment opportunities within the city, of real concern are the consequences of mind wandering or lack of job focus on driving, operating machinery and working on inner city projects. Images of future plans and construction, may impact on driver behaviour. Yanko and Spalek (2014) found that mind wandering while operating a vehicle caused behaviours that may lead to a higher risk of accident. Additionally distraction through mind wandering may jeopardise the driver’s ability to perceive and incorporate environmental cues (Galera, Orriols, et al, 2012).

It may be prudent for developers and city authorities to minimise street level distractions as much as practical, in an effort to unclutter vehicle level visual cues. Consideration should be given to restrict some future-focused advertising to predominantly pedestrian areas or lower speed limited roading, as they may be also detrimental to performance. The cities road network around the city is chaotic, as represented in some of the crowdsourced images. Road closures, re-routing and altered traffic management systems in addition to uneven surfaces are still prevalent throughout Christchurch. Taken alone the driving conditions are less than optimal and represent an increased hazard requiring enhanced not reduced task focus.

Where construction is prevalent it may be beneficial for safety to improve the clarity of road layouts and repair where able to minimise any additional cognitive load. Where possible the use of solid fencing of building sites to a minimum vehicle height could reduce mind wandering incidents with care to maintain a blank slate on these walls and not use them as advertising space.

5.3. Limitations

5.3.1. Crowdsourcing

While efforts were made to ensure ease of participation in providing images for the initial part of the experiment, uptake was slow. Difficulties with engagement meant that the process protracted much longer than anticipated and some of the photos may have not been a true representation of the current situation. Even with continued reminders and new initiatives the crowdsourcing took almost one year to complete. Given the state of recovery will be on-going and the themes captured in the images used will remain for an extended time frame, it is unlikely to have caused any confusion or invalidate the data.

The photos sourced were largely confined to the central city area and while this may be a limitation, particularly for those that no longer frequent the area, the images presented are generally easily identified. It is improbable that Christchurch residents would not recognise city structures and their significance to the community.

It may have been with hindsight that the words ‘positive’ and ‘negative’ held different meanings to each individual and may have generated unexpected consequences in the crowdsourcing. While the images used in the vigilance task clearly elicited the desired positive and negative thoughts, as confirmed by the independent rating process, some images sourced were ambiguous. While these ‘ambiguous’ images were not used in the current study, it would be interesting to study their effect on vigilance performance. Looking at the images as future or past biased photos, the ambiguous images are more representative of the past and so may mirror the ‘negative’ image condition. It would be prudent to take more care when choosing language in a future crowdsourcing exercise.

Crowdsourcing itself is an uncontrolled process, and all relevant perspectives may not have been represented. Demographic information was not collected from image suppliers, so no comment can be made around their diversity and how well they represented the population.

5.3.2. Vigilance

Care was taken to ensure the studied individuals were representative of the Christchurch population. Taken from Christchurch City Council reports, the 2013 mean age in the city was 36 years, which ties in well with the study mean age of 35 years. Of some concern may be the gender inequalities, with a ratio of 2.5 women:1 man. There are well documented gender differences in emotive responses (Ossowski, et al., 2011), and this may have enhanced or at least biased the results. However, given the likely low arousal qualities of the images used, any enhancement should have been minimised.

Additionally I did not make any effort to control for pre-test emotional, stress-state or use of stimulants. This may be particularly important given the right-hemisphere dominance in emotive processing (Helton, Dorahy, & Russell, 2011).

Most vigilance studies limit participants to right-handed individuals. The present study has included left-handed individuals in all analysis with the exception of the physiological fNIRS measures due possible hemispheric differences. This may have influenced results and perhaps future vigilance research could use both left and right handed participants to assess any differences in performance. One possible reason for removing left-handers is computer mouse use, which was mitigated in the current study. Other differences have not been explored.

While I confirmed consensus of perspective for the images used in the vigilance study, it is clear from the crowdsourcing process that there is a degree of disagreement. While care was taken to remove ambiguous images, there may have still been some images that did not conform to the condition they were placed in for some vigilance participants.

I did not include a condition without any disrupting images and it may be that even though the pixelated images contained no meaningful information, disruption may have occurred merely due to the colourful stimuli presented, contaminating the results.

5.3.3. fNIRS measures (rSO_2)

The equipment used to measure pre-frontal oxygenation is medical grade and highly sensitive to placement of the sensors and movement of the participant. However, only one individual was removed from the analysis due very low oxygenation levels, and all other results remained within normal limits.

5.3.4. Self-report measures

Self-report measures can be unreliable, particularly when participants are probed for historic information. Questionnaire items could have been embedded in the vigilance task to sample response throughout but this manner of questioning would likely cause qualitative changes in performance (Helton & Russell, 2012). A further possible limitation is the unbalanced numbers of males and females participating in the task and the possible differences in self-report. However this was compensated by balancing the ratio of male to female across each of the conditions.

5.4. Future research

While it seems likely that the disruption in the city is having impact on performance in general, it would be beneficial to investigate these findings further, particularly looking at whether any groups are more effected than others. Future research may be warranted focusing on young people to examine areas of concern enabling pre-emptive intervention. Particularly children who were in their formative years when the earthquakes struck may experience on-going cognitive disruptions that may have a negative impact in the future.

With hindsight, some of the images, particularly in the ‘negative’ set may have been contaminated with my wording in the crowdsourcing phase of the study. ‘Negative’ images focused on the destruction and disrepair that remains, with one image of infrastructure disruptions. Perhaps in fact the images became by default; those looking back (past) and those looking forward (future), and this likely influenced their impact in the vigilance task.

From personal experience and conversations, roading issues present a major problem and distraction for the population. It would be interesting to separate the two parts in the negative images to examine any differences in performance.

5.5. Conclusion

Christchurch is a city effected by a series of devastating earthquakes, with no finite end point. Within the last month of writing this a further severe earthquake occurred, which fortunately due to its location (west of Christchurch) caused no significant damage within the region. Residents are still suffering the enormous impact, made significantly more severe by the extremity of infrastructure damage. While the new normality has descended on the population, the underlying fear and uncertainly are regularly returned to the surface.

It is hard to fully conceive the extent of the problems for residents from outside the region. The earthquakes have brought a fear and feeling of insecurity to the population. We have lost most of our iconic buildings and indicators of our city. Facilities, whether they be sporting, retail, business, community have been taken away, with their return slow. Insurance and household repair processes crawl at a painful pace for many.

This study, suggests that the handling of the recovery process may be detrimental to health and safety. This is particularly relevant to vehicle and machinery operators within the central city, who require task focus. Imagery that reflects the future of the city may cause mind-wandering and have a concrete negative impact on the performance of critical tasks.

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7. Appendix A

Table 1

Mean hit rates in condition over periods (P)

Condition		P1 (pre-image	P2 (image)	P3 (image)	P4 (post-image)	P5 (post-image)
Control	M (SD)	.79 (.15)	.76 (.14)	.70 (.18)	.66 (.22)	.62 (.20)
Negative	M (SD)	.80 (.10)	.69 (.17)	.64 (.17)	.66 (.21)	.61 (.18)
Positive	M (SD)	.80 (.15)	.66 (.19)	.62 (.21)	.65 (.23)	.57 (.22)

Table 2

Mean false alarm rates in condition over periods (P)

Condition		P1 (pre-image	P2 (image)	P3 (image)	P4 (post-image)	P5 (post-image)
Control	M (SD)	.09 (.10)	.08 (.13)	.08 (.10)	.06 (.08)	.07 (.09)
Negative	M (SD)	.09 (.06)	.06 (.05)	.05 (.05)	.04 (.05)	.04 (.03)
Positive	M (SD)	.07 (.05)	.03 (.02)	.03 (.02)	.03 (.02)	.03 (.02)

8. Appendix B

Image rating task photos (description; location; type). Image conditions (Positive/Negative) are annotated in bold, images without annotation were used in the rating task but not the vigilance task.

1. Road to Sumner – damage homes and cliff face; residential; infrastructure and housing

Negative

2. Christchurch Cathedral – partially demolished/condemned; central city; religious/iconic

Negative

3. Condemned church – partially demolished buildings; residential area; religious

Negative

4. Road/infrastructure disruption – disrupted infrastructure; residential area: infrastructure

5. Empty lot – completely demolished buildings; central city; empty space

6. Mural – art; central city; aesthetic

Positive

7. Sculpture – art; central city; aesthetic

8. Archway – art; central city; aesthetic/significant

Positive

9. Art – art; central city; aesthetic

Positive

10. McKenzie and Willis – partially demolished buildings; central city; commercial

11. Road closures – infrastructure; central city; infrastructure

12. Remembrance chairs – gap filler; central city; remembrance

13. Victoria St Clock Tower – reconstructed/repaired; central city; iconic

14. Cardboard cathedral – reconstructed; central city; religious/focal

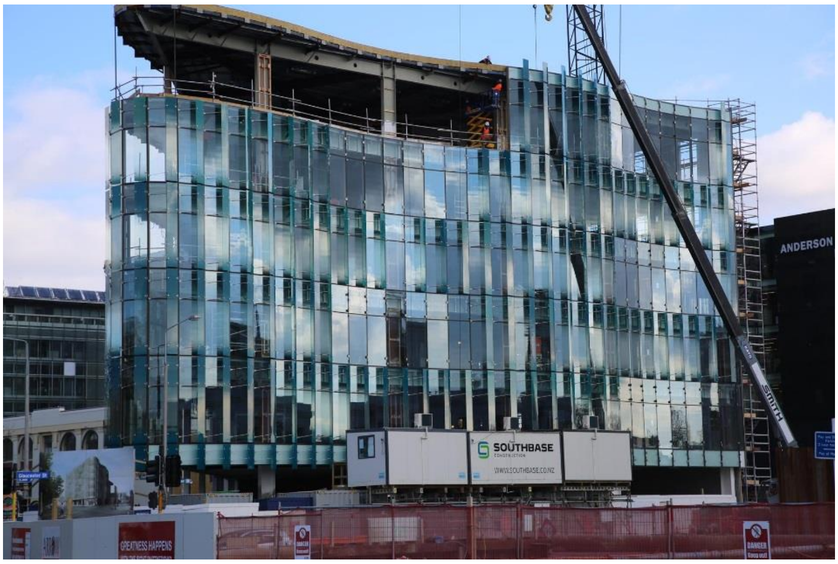
15. New Sports Facility site – empty site; central city; sport and recreation

16. Victoria St Church – reconstructed/repaired; central city; religious/architecture

Positive

17. Durham St – new construction; central city; commercial

Positive



18. Carlton Hotel – reconstructed; central city; commercial

19. Victoria St – new construction; central city; commercial

Positive

20. Durham Street – partially constructed buildings; central city; commercial

21. Re-start mall – new/reconstructed shopping precinct; central city; commercial

Positive

22. Unknown – partially demolished buildings; central city; commercial

23. Old Soul Square – partially demolished buildings; central city; night life

Negative

24. Victoria Mansions – condemned buildings; central city; residential

25. Cashel Mall – condemned buildings; central city; commercial

Negative

26. Cathedral – partially demolished buildings; central city; religious

Negative

27. Park – repaired infrastructure/recreation; central city; recreation

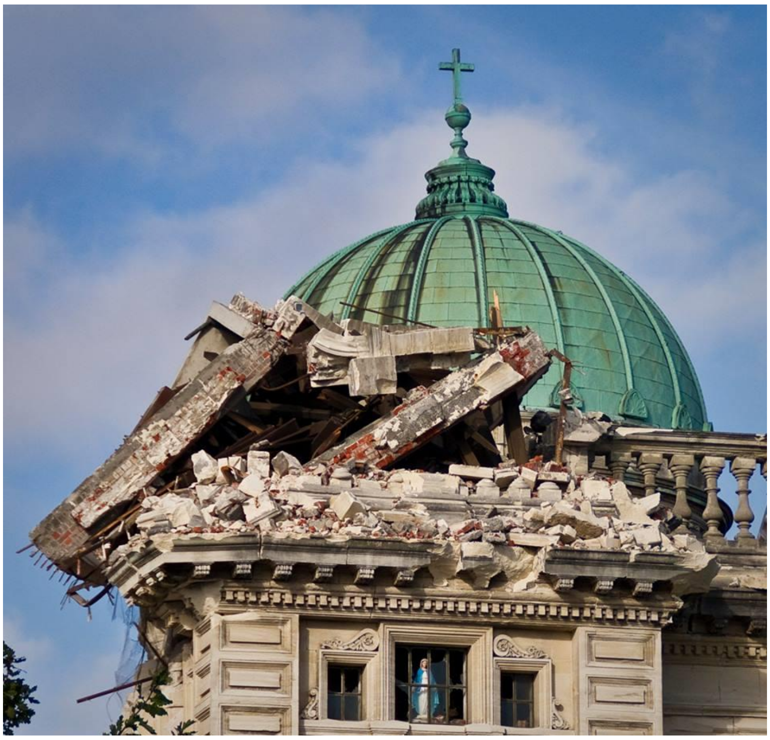
Positive

28. Durham St – roading disruptions; central city; infrastructure

Negative

29. Catholic Cathedral – partially demolished buildings; central city; religious

Negative



30. Bowenvale MTB Track Open – recreation; outer city; sport and recreation

Positive

31. Section – damaged buildings; residential area; house/home

Negative

32. Empty lot – completely demolished buildings; residential area

Negative

9. Appendix C

Information and Consent form

Department of Applied Psychology, UC – Research Projects

INFORMED CONSENT FORM FOR RESEARCH PARTICIPANTS

Information Sheet

Purpose of the Study. This experiment is part of the requirements for my Masters in Applied Psychology at University of Canterbury. The study is designed to monitor attention on a continuous task.

What will the study involve? The study will involve monitoring a computer screen and identifying targets (Dependent on the condition you are in, you may see some images). You will then fill out a self-report workload assessment form and demographic questions. The experiment lasts approximately 30 minutes.

Why have you been asked to take part? Participants must be at least 18 years of age and preferably right handed. Due to the nature of the research it is desirable that you have lived in Christchurch for at least 4 years.

Do you have to take part? Participation is entirely voluntary and you may withdraw at any time. Signing the consent form means you agree to take part in the study.

Will your participation in the study be kept confidential? Yes. I will ensure that your performance data and response to questions will not be individually linked to you. You identity will not be revealed in my dissertation document.

What will happen to the information which you give? The data will be kept confidential for the duration of the study. On completion of the thesis, they will be retained for a further six months and then destroyed.

What will happen to the results? The results will be presented in the thesis. They will be seen by my supervisor, a second marker and the external examiner. The thesis may be read by future students on the course. The study may be published in a research journal.

What are the possible disadvantages of taking part? I don't envisage any negative consequences for you in taking part.

Who has reviewed this study? This study has been approved by the Human Ethics Committee at the University of Canterbury.

Any further queries? If you need any further information, you can contact me: Nicola Hancock, 027 2999204 or my supervisor, Deak Helton, Psychology Department, University of Canterbury

If you agree to take part in the study, please sign the consent form.

I……………………………………agree to participate in Nicola Hancock's research study.

……………………………………………………. (Signature)

………………………………………………. (Date)